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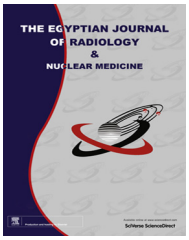

ORIGINAL ARTICLE

Acute right lower quadrant pain beyond acute appendicitis: MDCT in evaluation of benign and malignant gastrointestinal causes

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KEYWORDS

ARLQP;
MDCT;
Stratified enhancement

Abstract *Purpose:* To evaluate the role of MDCT in identification of various GIT pathologies beyond appendicitis that cause acute right lower quadrant abdominal pain and characterization of various distinguishing CT features as well as their predictive values in differentiating benign from malignant pathologies.

Materials and methods: This retrospective study included a total of 64 patients (34 females and 30 males with age ranges from 21 to 78 years) who presented with ARLQP (acute right lower quadrant pain). MDCT was done for all the patients; inclusion criteria included the presence of clinical, laboratory, and radiological evidence of the pathologic process. Pathological confirmation was obtained in 44 cases. All cases proved pathologically to be appendicitis were eventually excluded from the study cohort. Various CT morphologic parameters were recorded including the location of bowel wall involvement, the extent of involvement, the thickness of bowel wall and pattern of bowel wall thickening, the presence of stratified enhancement pattern, the transition from normal to abnormal wall, the degree of mesenteric fat stranding relative to the degree of wall thickening, the presence of excavating masses, and associated findings. A multivariate analysis was performed using covariates among the variable morphologic CT features.

Results: A stratified enhancement pattern of the bowel wall was the most reliable to indicate a benign active inflammatory process with the highest −ve predictive value of 91% and an abrupt

Abbreviations: ARLQP, acute right lower quadrant pain; MDCT, multidetector computed tomography; GIST, gastrointestinal stromal tumors; PV, predictive value

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zone of transition also proved to be the most significant in indicating a malignant process with a +ve PV of 74%.

Conclusion: Using a systematic pattern approach MDCT has proved to be an extremely useful noninvasive method for evaluation of patients with acute RLQP, allowing diagnosis and management of not only the most common conditions such as appendicitis but also less common conditions.

1. Introduction

Right lower quadrant abdominal pain is one of the most common causes of a patient visit to the emergency department. Although appendicitis is the most common cause of ARLQP, a broad spectrum of common and uncommon entities may mimic acute appendicitis both clinically and on diagnostic imaging, thereby creating a diagnostic challenge (1,2). Pathologic conditions involving the ileocecal area beyond appendicitis are responsible for a significant percentage of surgical admissions of patients who present with acute right lower quadrant pain. They include inflammatory processes (Crohn's disease, diverticulitis, epiploic appendagitis), infectious diseases, benign and malignant tumors, and miscellaneous conditions (cecal ischemia, typhlitis, omental infarct, cecal volvulus, duplication cyst) (3).

Numerous studies indicate that CT, when combined with a careful physical examination and an evaluation of laboratory results, is the diagnostic imaging modality of choice for patients with ARLQP (2,4,5). As a result, CT is increasingly used in the emergency department setting. Key benefits of CT over alternative modalities are that it not only accurately demonstrates the bowel wall but also outlines the pericolonic soft tissues and adjacent structures. CT cannot demonstrate subtle superficial mucosal changes revealed on barium studies, but it is a highly sensitive method for the detection of intramural disease and extraluminal extension of colonic disease. MDCT allows simultaneous acquisition of multiple images during a single rotation of the X-ray tube (6). However, although CT emerging as a modality of choice for the evaluation of the acute abdomen, ultrasonography (US) remains the primary imaging technique especially in young and female patients, when the limitation of the radiation exposure should be mandatory, limiting the use of CT in cases of nondiagnostic US and in all cases where there is a discrepancy between the clinical symptoms and negative imaging at US (7).

This article analyzes the typical imaging findings and key clinical elements of the most common entities involving the ileocecal area that were under recognized before a common use of MDCT.

1.1. Inflammatory conditions

Crohn's disease has a propensity to involve the terminal ileum and the cecum and less commonly the appendix. Most patients experience chronic symptoms; however, acute exacerbations or

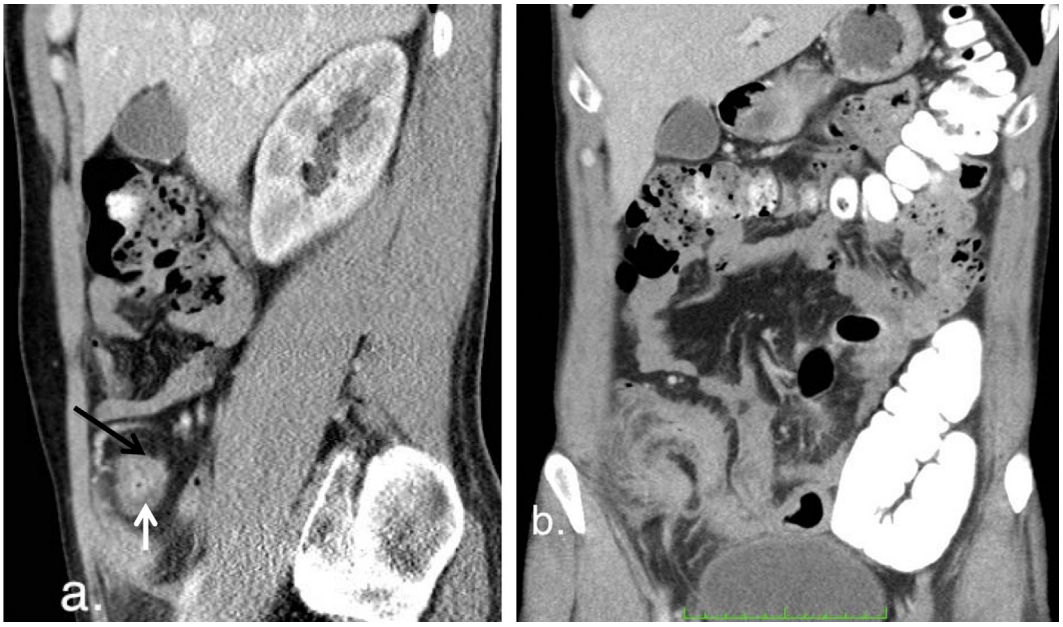

Fig. 1 Crohn's disease: A 30 year old male patient presented with ARLQP. (a) sagittal and (b) coronal reformatted images from Intravenous contrast-enhanced CT scan of a case of Crohn's disease revealed a markedly thickened cecum and terminal ileum with mural stratification: water halo sign where a higher-attenuation inner layer (white arrow) and an outer ring of gray attenuation are seen (black arrow).

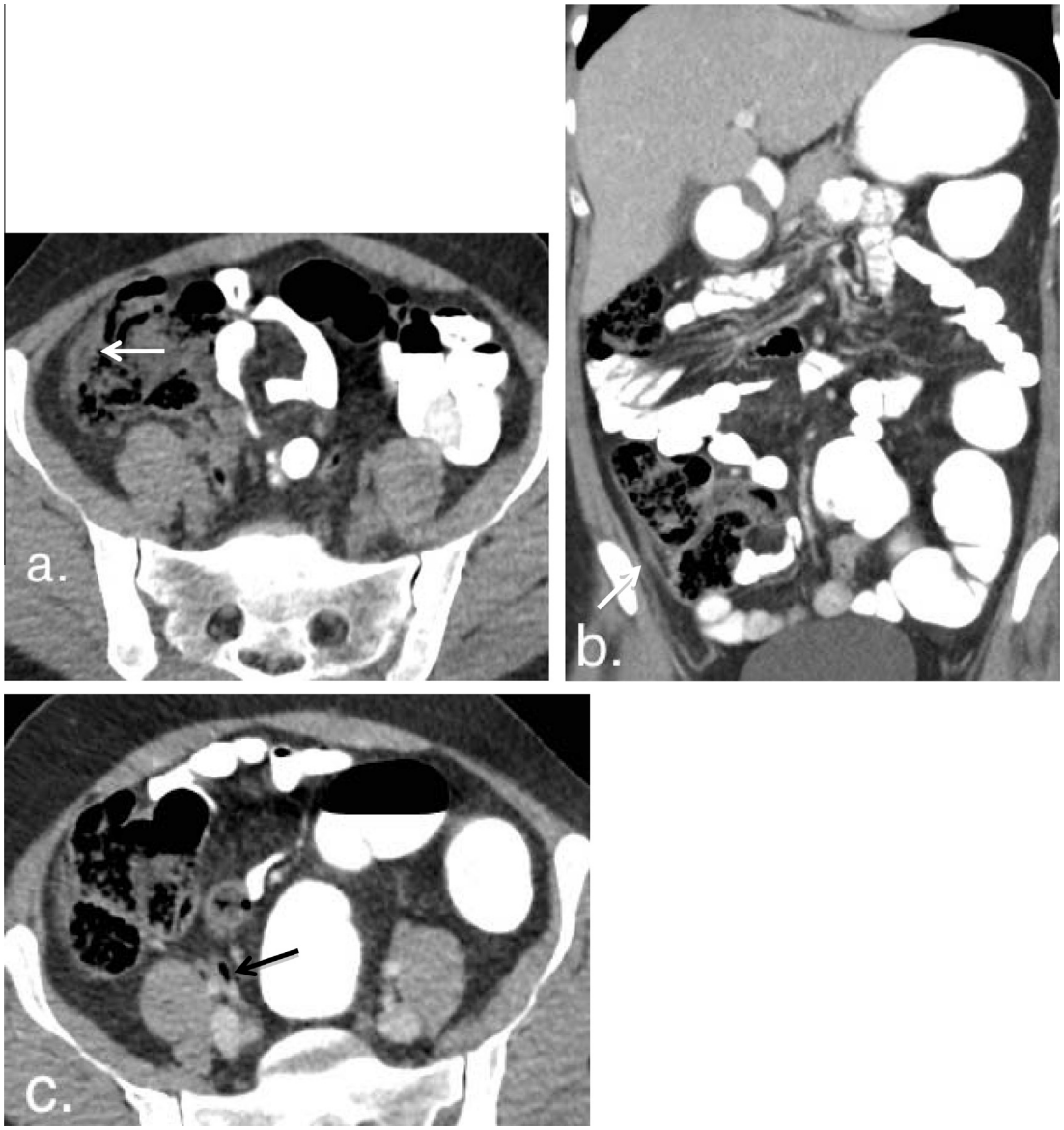

Fig. 2 33-year-old woman with right abdominal pain. (a) Axial and (b) coronal CT scan shows fat-containing lesion (arrows) with hyperattenuating rim and fat stranding (whiter arrows) in right lower quadrant right lateral to cecum, consistent with epiploic appendagitis. (c) Axial CT at a lower level shows the appendix of normal caliber with intraluminal air and contrast confirming normal appendix (arrow).

complications may lead to acute abdominal pain. Long segmental circumferential wall thickening of the terminal ileum and cecum, and inflammation that is centered away from the appendix and secondary sign as fibrofatty proliferation are the major features that help differentiate Crohn's disease from the reactive changes seen in appendicitis. Multiplanar reformations are particularly helpful in identifying complications as strictures, abscesses and fistulous tracts which include enterovesical enterocutaneous, perianal and rectovaginal fistulas (8,9).

Infectious ileocolitis particularly *Yersinia enterocolitica*, *Campylobacter jejuni*, and *Salmonella enteritidis* may lead patients to seek medical attention for acute abdominal pain indistinguishable from that of appendicitis (10). Although most cases do not require imaging owing to the self-limited nature of the symptoms, CT may be necessary in patients with severe or persistent pain for differentiation from alternative diagnoses (11). Nonspecific findings, such as circumferential mural thickening of the terminal ileum and cecum with preservation of a layered enhancement pattern and adjacent adenopathy, may be seen at CT. Stranding of the pericolic and mesenteric fat, a small amount of ascites, and air-fluid levels may or may not be associated (10–12).

Neutropenic colitis (typhlitis) is an inflammatory condition seen in immune compromised patients e.g. acute leukemia, or post transplantation states. It characteristically affects the cecum and ascending colon but may also involve the terminal ileum and the appendix and is frequently indistinguishable clinically from acute appendicitis. However, the length of the cecum and right colon involved by typhlitis is generally much

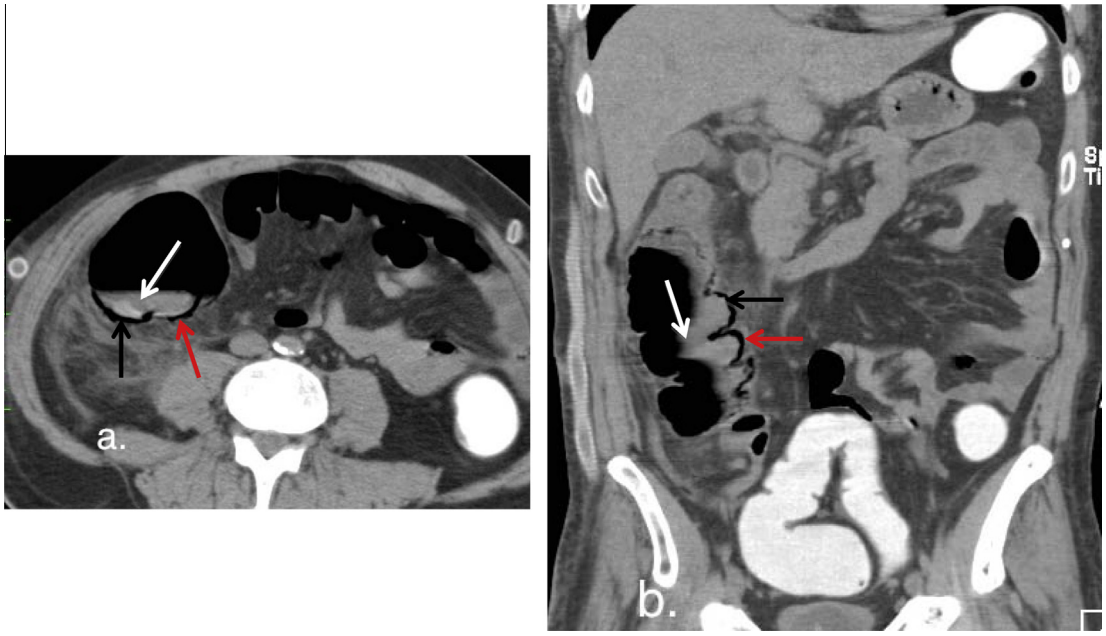

Fig. 3 56-year-old male patient with acute right lower quadrant pain post ilioileal arterial anastomosis. Axial CT scan shows pneumatosis of cecum and ascending colon. Black attenuation: rounded mural gas attenuation collections (black arrows), as well as the outer margin of the colonic wall (red arrows), lumen (white arrow), and pericecal fat stranding. Surgery confirmed infarction and the patient underwent right hemicolectomy.

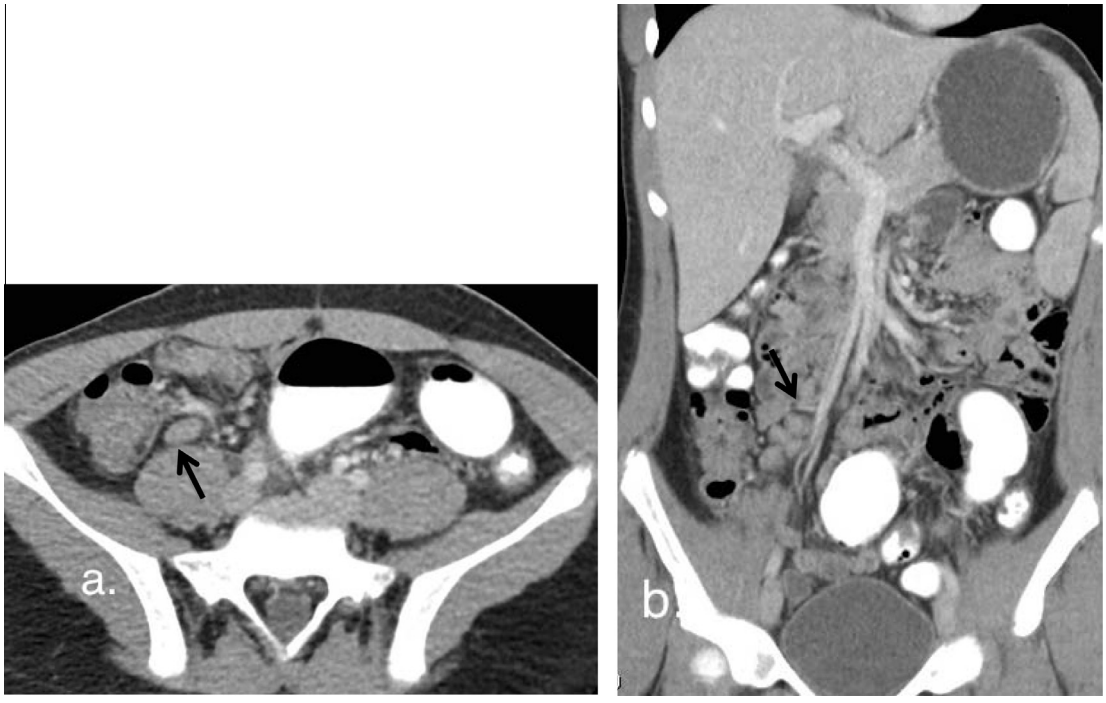

Fig. 4 Mesenteric adenitis in a 19-year-old male patient with ARLQP and low-grade fever. (a) Axial and (b) Coronal volume-rendered CT images show multiple enlarged mesenteric lymph nodes (arrows) without abnormalities in the ileocecal region.

greater than that associated with appendicitis, bowel thickening is more asymmetric in appendicitis than in typhlitis, and the presence of known risk factors favors the diagnosis of typhlitis (neutropenic colitis) (13).

Diverticulitis of the colon is one of the most common causes of acute abdominal pain in elderly patients. It typically manifests as left-sided lower abdominal pain, as the left and sigmoid colon are predominantly affected. Less often, the right colon

and cecum may be involved, clinically mimicking appendicitis (14,15). When the cecum or right colon is affected, demonstration of inflamed diverticula, usually located at the level of maximum pericolic inflammation, along with a normal appendix are key elements in differentiation from appendicitis (16). Differentiation from malignancy involving the right colon and cecum may be difficult or in some cases impossible on the basis of CT findings (4,17–19). Although nonspecific, the findings of a preserved stratified enhancing pattern of the thickened colon wall, fluid in the mesentery, and engorgement of adjacent mesenteric vasculature favor the diagnosis of diverticulitis (9,20). Acquired Ileal diverticula result from mucosal herniation of the bowel at sites of vascular entry and are therefore located on the mesenteric border of the terminal ileum, less than 7.5 cm from the ileocecal valve. They are usually asymptomatic and are encountered more often in men over the age of 40 years (21). The clinical presentation may be indistinguishable from that of acute appendicitis (22,23). In contradistinction to acquired ileal diverticula, Meckel diverticulum is located on the antimesenteric border, approximately 60 to 100 cm from the ileocecal valve (24,23). The CT appearance of Meckel diverticulitis is a blind-ending pouch containing fluid and air or particulate material, with mural thickening, hyperenhancement, and surrounding mesenteric inflammation (16,23,25). Appendiceal diverticula are uncommon. Clinically, appendiceal diverticulitis differs from acute appendicitis in that it affects older patients (> 30 years of age), has a more insidious onset, and lacks the characteristic migratory pain

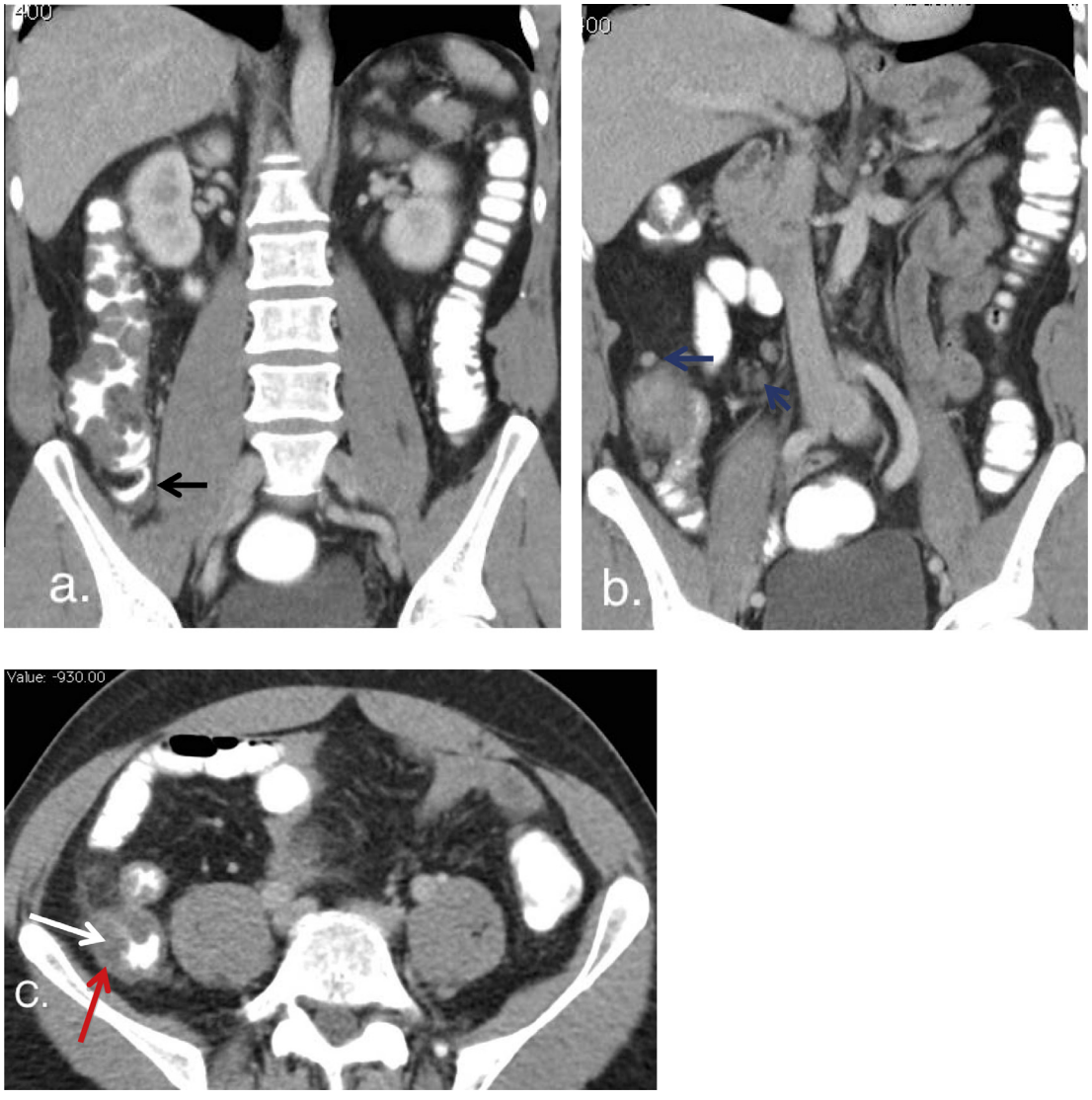

Fig. 5 A 52 year old male patient presented with right iliac fossa pain. (a), (b) coronal volume rendered CT images and (c) axial image from an intravenous contrast-enhanced CT scan show concentric wall thickening of the, cecum, a portion of the ascending colon, and distal part of the terminal ileum. Water halo sign: an outer enhanced layer (red arrow in c) surrounding a water attenuation layer (white arrow). Luminal contrast material is also seen. Other signs aiding the diagnosis include long segment affection, gradual transition, enlargement of the pericolic and mesenteric lymph nodes (blue arrows in b) as well as haziness and fibrofatty proliferation of surrounding fat. Identification of the normal contrast filled appendix (black arrow in a) and lack of periappendiceal fat stranding help to exclude appendicitis. It was pathologically proven to be infectious ileocolitis.

location seen in classic appendicitis. At CT diverticular inflammation is seen as prominent enhancement of the diverticulum wall with surrounding fat stranding. Features of reactive inflammatory changes in the appendix, such as increased diameter, wall thickening, and hyperenhancement, can lead to a misdiagnosis of appendicitis at CT (14).

1.2. Malignancies

ARLQP may be the initial presentation of a malignancy involving the ileocecal region, such as adenocarcinoma, lymphoma, gastrointestinal stromal tumor, or metastasis, especially in the event of a complication, such as perforation or abscess (26).

Adenocarcinomas of the cecum account for one-fourth of all colonic adenocarcinomas (26). They have the same MDCT features as all other colonic adenocarcinomas, including marked asymmetric wall thickening, short segment involvement, and abrupt change from normal to abnormal segments of colon. Although they tend to be large, polypoid, and bulky, they rarely cause obstruction and often grow without clinical manifestations for long periods of time (4). Adenocarcinomas of the terminal ileum are primarily annular and constricting. Differentiation of the infiltrative form of terminal ileal adenocarcinoma from stenosing Crohn's disease can be difficult; however, certain features of Crohn's disease as well as the length of bowel involved may be helpful in this context (27). Adenocarcinomas of the appendix are less common than

Fig. 6 A 31 year-old male patient presented with acute right lower quadrant pain. (a) Sagittal, (b) axial and (c) coronal CT images after oral and intravenous contrast show focal asymmetric thickening of the cecal wall with adjacent stranding of the pericolonic fat, associated with a diverticulum (arrows in a and b), and a normal appendix (arrow in c).

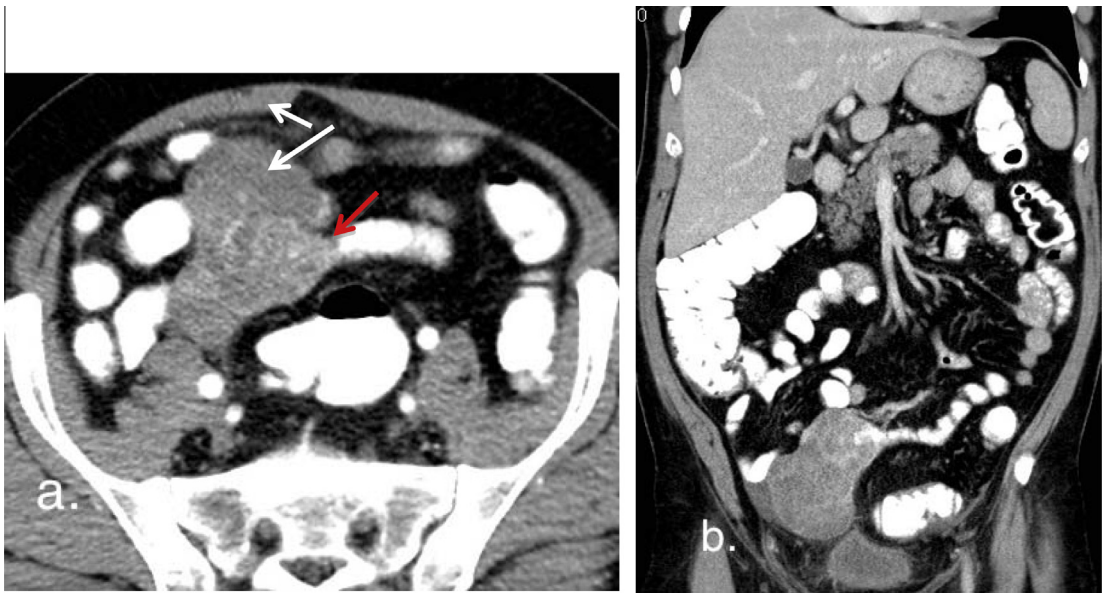

Fig. 7 A 60 year-old patient presented with right lower quadrant pain. CT images (a) axial and (b) coronal revealed an exophytic mass arising from a small bowel (distal ileal) loop in the right lower quadrant shows the gray attenuation pattern with attenuation similar to that of adjacent muscle (white arrows). GIST was proven post surgical excision. Morphologic sign of the sharp angular margins (red arrow in a) aided diagnosis of malignancy with the gray attenuation pattern.

appendiceal carcinoid tumors but are more likely to be detected at MDCT due to their larger size and higher rate of complications (28). The majority of these tumors are mucin rich; thus, their diagnosis at CT hinges primarily on detection of the resulting mucocele with irregular soft-tissue thickening of the mucocele wall and surrounding fat.

Carcinoid tumors: Distal ileal carcinoid tumors are likely to be small, but the thinner collimation that is possible with MDCT allows their diagnosis (29). They usually manifest as hypervascular nodular wall thickening or a smooth submucosal mass. As they enlarge, they rarely cause annular narrowing, but there may be kinking of the bowel wall with narrowing of the lumen. Manifestations of mesenteric desmoplastic reaction, sometimes without an evident mass component, are the most common and striking CT findings. This reaction manifests as an ill-defined, soft-tissue-attenuation mass with mesenteric stranding in a stellate pattern extending toward the surrounding bowel loops. The mass contains calcification in up to 70% of cases. Carcinoid tumors of the appendix are usually less than 1 cm in size and found in the distal third of the appendix. They are most often discovered at surgery or pathologic examination. Symptomatic obstructing carcinoid tumors near the base of the appendix will usually manifest at CT as appendicitis; they sometimes manifest as diffuse mural thickening at MDCT (28).

Lymphoma: The ileum and the cecum are the most common sites of involvement by primary lymphoma in the small and large bowel, respectively and may also extend to the appendix. Lymphomas predominantly affect men in the 6th and 7th decades and often manifest as abdominal pain and weight loss. Lymphoma of the ileocecal region may occur in four forms: circumferential or constrictive, polypoid, ulcerative, and aneurysmal (30). Most commonly it manifests as single or multiple segmental areas of circumferential thickening with homogeneous attenuation and poor enhancement. In this form it may mimic adenocarcinoma, but in the former, the segment of bowel involved is usually longer; the transition from tumor to normal bowel is much more gradual; and associated, possibly bulky mesenteric and retroperitoneal lymph nodes are usually seen encroaching on the vessels from both sides. The polypoid form may act as the leading point for intussusception (30). In the ulcerative form, fistulous tracts develop between adjacent bowel loops from an ulcerated mass. Finally, the aneurysmal form involves dilatation of the lumen or cavity of the mass, which is significantly larger than the proximal and distal bowel segments with bowel entering and exiting the mass (31).

GIST of the ileocecal area may rarely occur in the distal ileum and, even more rarely, in the cecum. The diagnosis of GIST can be suggested by the presence at MDCT of a large, well-circumscribed tumor arising from the ileum that is usually predominantly extraluminal with a heterogeneously enhancing soft-tissue rim surrounding a necrotic center (32). GIST of the ileum has many features similar to those of lymphoma. The presence of associated lymphadenopathy favors the diagnosis of lymphoma, since the lymphatic route is not a common mode of tumor spread in GIST (33).

Secondary malignant involvement: Neoplastic lesions may spread to the small bowel hematogenously, by means of direct invasion, or by means of intraperitoneal seeding (the right lower quadrant at the termination of the small bowel mesentery being one of the predominant sites of implantation). Direct invasion from the right ovary usually involves the cecum and distal ileum by means of extension through the small bowel mesentery of the ileum (34). Multi-detector row CT features include increased bowel wall thickness, annular stenosis with marked luminal narrowing and angulation, and a polypoid mass that may occasionally cavitate (34).

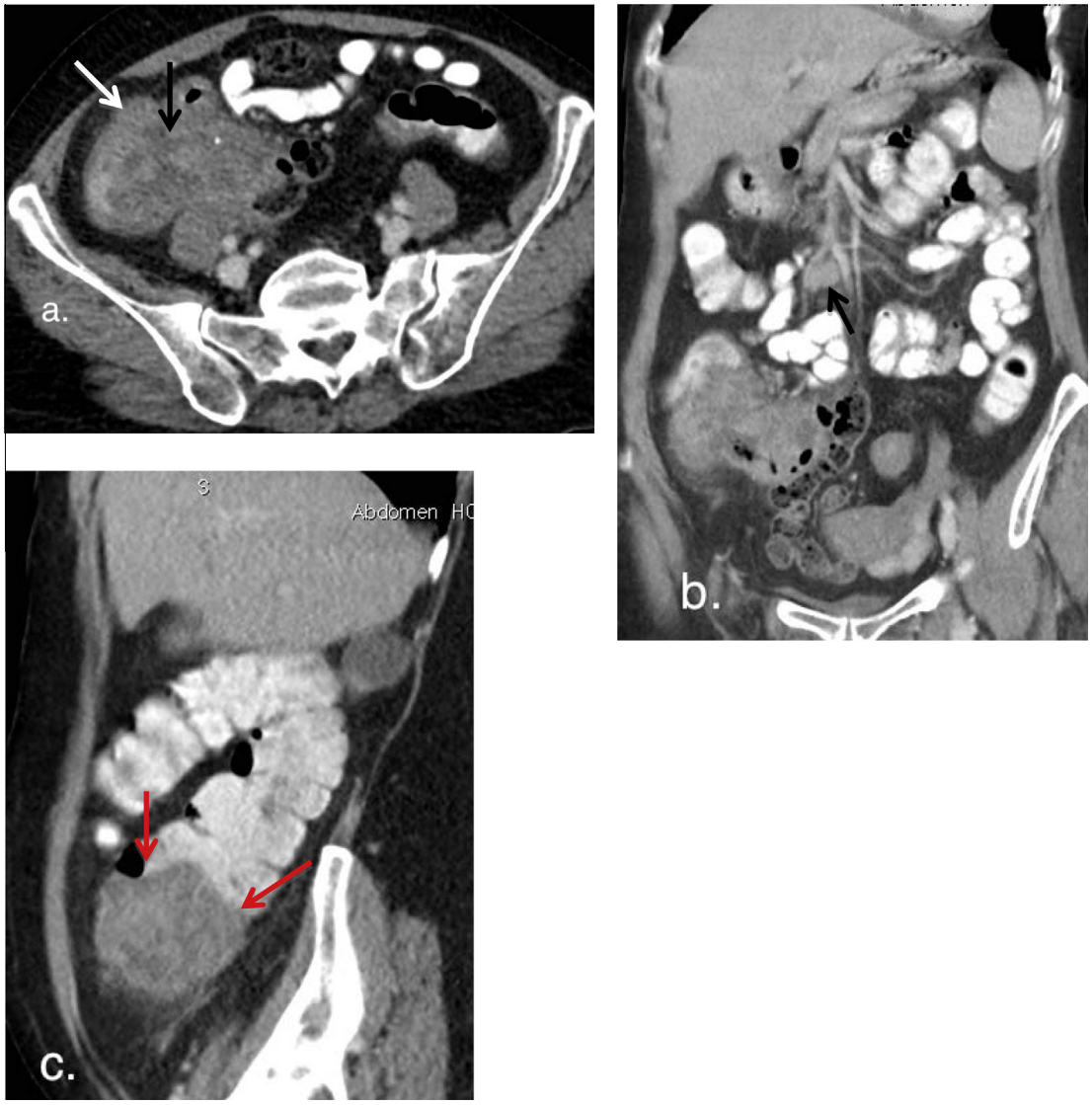

Fig. 8 Lymphoma of the ileocecal valve in a 65-year-old female patient with ARLQP, low-grade fever, and weight loss. (a) Axial and (b) coronal CT images show incomplete water halo sign scan: a homogeneous mass of soft-tissue attenuation arising from the ileocecal valve and filling the cecal lumen, with no small bowel obstruction proximally, the narrowed lumen is surrounded by an asymmetrically thickened, lower-attenuation layer (black arrow). The surrounding outer layer is incomplete (white arrow). Note the abrupt, upper margins of the mass (red arrows in c). Associated enlarged mesenteric lymph nodes are noted (black arrow in b).

1.3. Miscellaneous

Epiploic appendagitis is thought to occur as a result of spontaneous torsion, ischemia, or inflammation of an epiploic appendage of the colon (13). Patients present with acute abdominal pain that can mimic appendicitis. Characteristic findings include an oval, paracecal fatty mass, hyperattenuating rim surrounding the mass; and, sometimes, a high-attenuation central dot. The cecal wall may show mild local reactive thickening that is disproportionately less severe than the paracecal inflammatory changes (35).

Omental infarction is caused by interruption of blood supply to the omentum due to torsion or venous thrombosis. Primary (idiopathic) infarction is usually precipitated by coughing, straining, or overeating. Secondary infarction occurs from vascular damage (thrombosis or torsion) related to trauma, surgery, hernia, or adhesion. The CT features of acute omental infarction include a solitary, well-circumscribed, triangular or oval, heterogeneous fatty mass, sometimes with a whorled pattern of concentric linear fat stranding. It is characteristically situated between the anterior abdominal wall and the transverse or ascending colon, corresponding in location to the greater omentum (10,36,37).

Primary mesenteric adenitis is defined as the presence of clustered (more than three) right-sided lymph nodes in the small bowel mesentery or anterior to the psoas muscle, usually larger than 5 mm, without an identifiable acute inflammatory condition (12,38). Most cases are believed to be related to an underlying infection of the terminal ileum (13). Patients usually present with acute RLQP, fever, and leukocytosis.

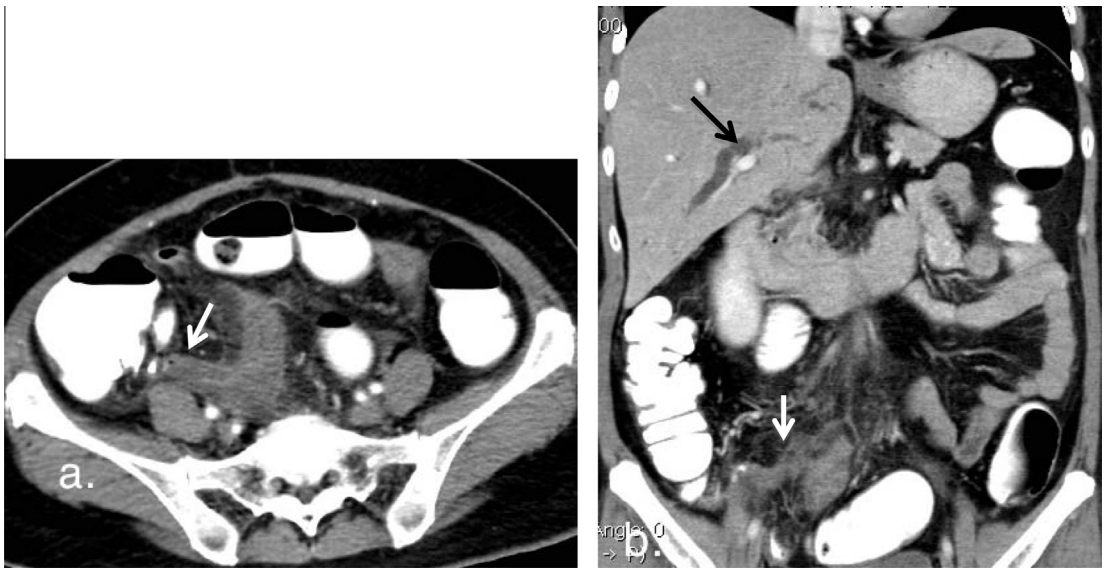

Fig. 9 Adenocarcinoma of the appendix manifesting as acute appendicitis in a 56-year-old female patient with acute right lower quadrant pain and leukocytosis. (a) Axial and (b) coronal contrast-enhanced CT scan shows a soft-tissue mass that is seen to replace the appendix (white arrows in (a and b). Note the soft-tissue infiltration of the surrounding fat. Intrahepatic biliary radicals dilatation (black arrow in b) from metastatic lymph nodes in the porta hepatis.

The disorder is more frequent in children. In adults, secondary mesenteric adenitis is far more frequent and may be seen in many local inflammatory conditions such as appendicitis, diverticulitis, and Crohn's disease or as part of a systemic inflammatory condition SLE or HIV infection (39).

The objective of this study is to evaluate the role of MDCT in identification of various GIT pathologies beyond appendicitis that cause acute right lower quadrant abdominal pain and characterization of various distinguishing CT features as well as their specificity in differentiating these various pathologies.

2. Materials and methods

This retrospective study included a total of 64 patients (34 females and 30 males with age ranges from 21 to 78 years) who presented to the emergency department and outpatient clinic of Ain Shams University hospitals with ARLQP from the period between October 2011 and October 2013. Initial evaluation of all patients included physical examination, laboratory tests, and imaging studies. When possible, detailed clinical history was obtained from a non sedated patient with special emphasis on pain's location, radiation, and movement as well as onset, duration, severity, and quality of pain.

The patient's general appearance and vital signs were helpful to narrow the differential diagnosis. Pelvic examination and ultrasonography were performed especially in female patients of childbearing age to exclude conditions such as ruptured ectopic pregnancy, salpingitis, a tuboovarian abscess, a necrotic leiomyoma, endometriosis or ovarian torsion. Laboratory tests varied based on the clinical situation.

Inclusion criteria included the presence of clinical, laboratory, radiological, and in many cases pathological confirmation of the nature of the lesion. All cases proved pathologically to be appendicitis were eventually excluded from the study cohort. Follow up MDCT studies were performed for nonsurgical candidates who were diagnosed to have benign infectious or inflammatory lesions.

3. MDCT Protocol

Scanning was performed from the dome of the diaphragm through the pubic symphysis with a 320 row-MDCT scanner (Toshiba Aquilion One 320-row detector). We injected 120 mL of nonionic contrast material intravenously at a rate of 3 mL/s. Because the majority of lesions were discovered in an emergency context, scanning protocol with respect to oral or rectal administration of water or contrast material varied depending on the clinical condition of the patient and the suspected abnormality. When Rectal contrast was administered this was done via a soft catheter with a balloon. The catheter was generously lubricated with gel prior to insertion. The catheter was inserted 2–3 inches into the rectum. Contrast was administered via gravity using an enema bag while the patient is on the scanning table. 600 mL to 1 L of contrast was given. Imaging was performed during the portal venous phase as determined by bolus tracking and automated triggering technology. The parameters were 140 kVp; 350 mA; pitch, 1.75; 17.5 mm per rotation; and 0.5 s per rotation. The axial data were reconstructed twice, first with a 5-mm thickness at 5-mm intervals and then with a 0.625-mm thickness at 0.5-mm intervals. The second set of reconstructed axial images were then reformatted in the coronal plane with a thickness of 3 mm at 5-mm intervals. The reconstructions were performed on a commercially available console system devoted to rapid reconstruction (Toshiba Aquilion) that consists of symmetric multiprocessing dual Intel Xenon 2.66-GHz processors (Intel Corp.) with a CT image generator capable of reconstructing from 6 to 10 images per second.

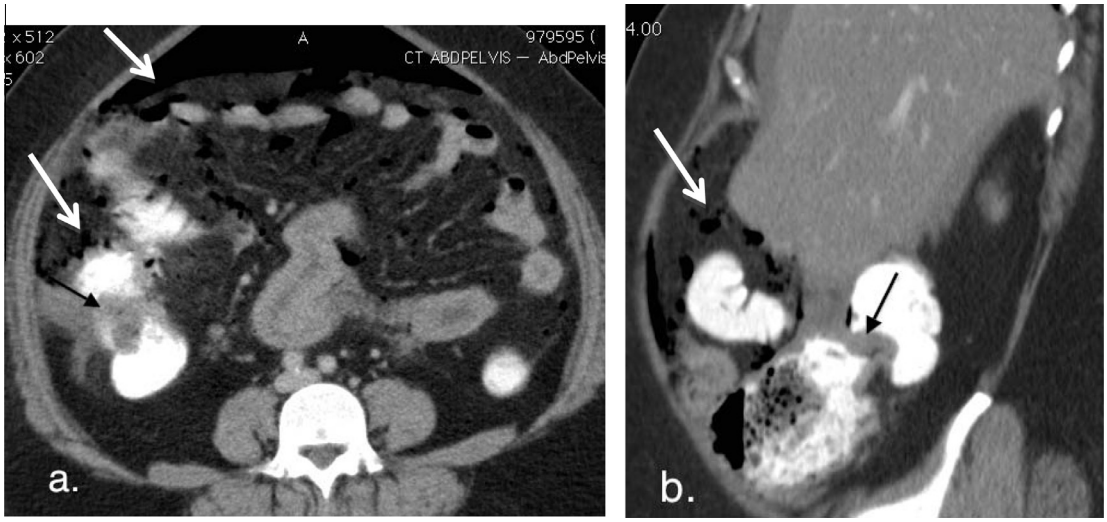

Fig. 10 Perforating adenocarcinoma of the distal ascending colon in a 44-year-old female patient with fever, ARLQP. (a) Axial and (b) sagittal CT images demonstrate the gray attenuation; the thickened wall of the distal ascending colon with attenuation similar to that of adjacent muscle with abrupt, angular margin of the mass (black arrows). Note the extraluminal air and pnuemoperitoneum (white arrows).

The study protocol was approved by the Institutional Ethics Committee of School of Medicine, Ain Shams University, Egypt.

3.1. Image analysis

The 1-mm thick axial and 3-mm-thick coronal images were transferred to a PACS workstation (Toshiba Aquilion) as a separate series of images for interpretation. Two experienced radiologists with at least 3 years experience in gastrointestinal imaging evaluated all the images independently.

The CT morphological and enhancement features of each lesion were recorded on a data sheet including:

- Location of bowel wall involvement,
- Extent of involvement (focal or segmental, if segmental single or multiple segments, short or long segment),
- Thickness of bowel wall and morphology of bowel wall thickening (i.e. smooth or irregular, concentric or eccentric),
- Transition from normal to abnormal wall (abrupt or gradual),
- Attenuation patterns of the enhanced bowel wall (white, gray, water halo sign, fat halo sign and black),
- Degree of mesenteric fat stranding relative to the degree of wall thickening),
- Presence of excavating masses,
- Associated findings (lymph nodes, mesenteric stranding, fibrofatty proliferation, abscess and sinus tracts, desmoplastic reaction, solid organ abnormalities).

Based on combination of these morphologic and enhancement abnormalities of thickened bowel wall as well as extra intestinal manifestations, lesions involving the ileocecal area were classified into two groups: group A including those lesions showing benign criteria and group B including those lesions favoring malignant criteria.

When the lumen is distended, *bowel wall thickening* of less than 2 cm was considered benign whereas wall thickening greater than 3 cm suggested a neoplastic condition; when the lumen is collapsed normal thickness may be 3–4 mm (29,40). *The length and pattern of bowel wall involvement* were also used in narrowing the differential diagnosis: long segments of involvement (> 10 cm) were toward a diagnosis of a benign condition (Fig. 5). Irregular and eccentric bowel wall thickening favored a malignant condition (Fig. 7), whereas smooth and concentric mural thickening were suggestive of a benign inflammatory condition. *The transition from normal to abnormal wall* provided an additional clue in distinguishing benign from malignant conditions; abrupt transition from normal to abnormal bowel wall raised suspicion of a malignant process (31) (Figs. 7,8 and 10).

The bowel wall attenuation and stratification characteristics included five main categories; the white pattern represents avid contrast material enhancement that uniformly affects most of the thickened bowel wall. If the bowel wall is enhanced to a degree equal to or greater than that of venous opacification in the same scan, it should be classified in the white attenuation pattern. It is best appreciated in loops of bowel not distended with a contrast material since intense intestinal opacification may be confused with a luminal oral contrast material (41). Common diagnoses with this pattern include idiopathic inflammatory bowel diseases and vascular disorders (26,42).

The gray pattern is defined as a thickened bowel wall with limited clear-cut enhancement whose homogeneous attenuation is comparable with that of enhanced muscle (Fig. 7). The gray pattern is the least specific of the five attenuation categories for diagnosis and it is common in both benign and malignant diseases and should therefore be combined with morphologic observations (41).

The water halo sign indicates stratification within a thickened bowel wall that consists of either two (halo sign) or three (target sign) continuous, symmetrically thickened layers. A halo sign with two layers is composed of either a higher-atten-

uation outer annular ring (muscularis propria) surrounding a second, luminally oriented annular ring of gray attenuation (Fig. 5) or a higher-attenuation inner layer and an outer ring of gray attenuation (Fig. 1) (1,43,44). A third variant, the target sign, is composed of three rings: outer high-attenuation muscularis propria, a middle ring of gray attenuation, and a luminally oriented ring of high attenuation. The lower-attenuation (gray) layer of the water halo sign is believed to represent edema. For simplicity sake, we use the water halo sign to refer to all three of these configurations. Common diagnoses with this sign include idiopathic inflammatory bowel diseases, vascular disorders, infectious diseases, and radiation damage. The uncommon diagnosis in which this pattern occurs is malignancy (40,41).

The fat halo sign refers to a three-layered target sign of thickened bowel in which the middle or "submucosal" layer has a fatty attenuation of below-10HU (1,38). The observation of fat halo sign in the small intestine, is for all intents and purposes, diagnostic of Crohn's disease and by itself is a sign of a chronic phase. In the colon it occurs in Crohn's disease and ulcerative colitis. Black attenuation is the equivalent of pneumatosis (Fig. 3), and this pattern is commonly seen in ischemia, infection, and trauma (40).

The presence of fat stranding adjacent to a thickened bowel segment suggested an acute inflammatory condition unless perforation 2ry to a malignant tumor has occurred. Fat stranding that is disproportionately more severe than the degree of wall thickening is one of the findings that suggested an inflammatory disease particularly one that is centered in the mesentery: diverticulitis (Fig. 6), epiploic appendagitis, (Fig. 2) omental infarction, and appendicitis (36).

Associated findings including lymph nodes; mesenteric fat stranding and calcification; abscess, sinus tracts, and fistulas; proliferation of fat; vascular occlusion, mesenteric vein gas; and solid organ abnormalities all contributed to establishing the final diagnosis.

The final diagnosis was based on histopathological results of mucosal biopsies in 13 cases, surgical specimens in 31 cases and on the combination of laboratory tests including a complete blood count, ESR and C- reactive protein, blood cultures, stool cultures, urine analysis and serologic tests for specific infections, tumor markers (e.g. CEA, CA) and imaging studies before and following treatment in 20 cases.

For group A lesions: those proved to be benign by histopathologic, laboratory tests and follow up post-therapeutic studies were considered true negative, and those proved to be malignant were considered as false negative. For group B lesions: those confirmed to be malignant were considered true positive and those turned out to be benign by histopathology were considered false positive.

3.2. Statistical analysis

The diagnostic validity for each of the previously mentioned CT parameters in differentiating benign non neoplastic from malignant neoplastic lesions were calculated including predictive value for a positive test (+ve predictive value) and predictive value for a negative test (−ve predictive value). A multivariate analysis was performed using covariates among the variable morphologic CT features. We calculated *P* values of each predictive variable using the Chi-square test. The probability of error at 0.05 was considered significant, while at 0.01 and 0.001 are highly significant.

4. Results

Using a combination of various CT parameters: group A included 41 probably benign and group B included 23 probably malignant lesions. The final histopathologic outcomes of mucosal biopsies and surgical specimens in 44 cases were as follows: 21 malignant tumors (including 11 adenoacrcinomas of cecum, appendix and ascending colon (Figs. 9 and 10), 6 ileocecal lymphomas, 2 carcinoids of appendix and cecum, 1 GIST of ileum and one metastatic involvement of the ileum) and 23 benign conditions including (10 Crohn's disease, 8 diverticulitis of cecum, ileum, and appendix, 1 ischemic colitis of the cecum and 1 case of typhlitis and 1 tuberculous enterocolitis). In the remaining 20 cases where the final diagnosis was based on a combination of laboratory tests and pretherapeutic and follow up imaging studies there were: (5) infectious enterocolitis, (4) diverticulitis (Fig. 4), (4) Crohn's disease, (3) epiploic appendagitis, (2) mesenteric adenitis, (1) omental infarct, one inflammatory response to a tuboovarian abscess and two cases did not respond to conservative treatment and proved finally to be neoplastic in nature (Table 1).

The multivariate analysis including the predictive values and levels of significance of each of the fore listed CT parameters in differentiating benign from malignant neoplastic lesions we analyzed are given in Table 2.

5. Discussion

Cross-sectional imaging with helical CT and more recently with multidetector CT has proved to be an extremely useful noninvasive method for evaluation of patients with acute right lower quadrant abdominal pain, since the history and physical examination results are not always specific for distinct diseases and findings of plain radiography are often non contributory

Table 1 The final diagnosis of the 64 cases.

	Malignant	Benign	Total
Pathological justification	21 (11 adenocarciomas, 6 lymphomas, 2carcinoids, 1 GIST, 1 metastatic involvement)	21 (9 Chrons, 8 diverticulitis, 2 ischemic colitis, and 2 typhlitis)	42
Combination of laboratory and imaging studies	2 (1 lymphoma and 1 carcinoid)	20 (6 Chrons, 4 diverticulitis, 4 infectious colitis, 2 epiploic appendagitis, 2 mesenteric adenitis, 1 omental infarct, one inflammatory response)	22
	23	41	64

Table 2 The multivariate analysis including the predictive values and levels of significance of each of the different CT parameters in differentiating benign from malignant neoplastic lesions.

	Benign	Malignant	+PV (true+/true and false +)	−PV (true−/true and false−	*P*	sig
Degree of bowel wall thickening in distend bowel						
< 2 cm	26	4	19/34 = 55.8 %	26/30 = 86.6%	< 0.05	S
> 3 cm	15	19				
Total	41	23				
Extent of bowel wall thickening						
Long segment (segmental) ⩾ 10 cm	29	5				
Short segment (focal) < 10 cm	12	18	18/30 = 60 %	29/34 = 85%	< 0.05	s
Total	41	23				
Pattern of bowel wall thickening						
Smooth symmetric	27	3	20/34 = 58.8%	27/30 = 90%	< 0.05	S
Irregular asymmetric	14	20				
Total	41	23				
Transition zone						
Smooth	35	6				
Abrupt	6	17	17/23 = 74%	35/41 = 85.3 %	< 0.05	S
Total	41	23				
Pattern of bowel wall enhancement						
Water halo (double halo or target sign)	33	3	20/28 = 71.4%	33/36 = 91.6%	< 0.005	HS
Gray pattern	8	20				
Total	41	41				
Degree of fat stranding						
Marked/disproportionate	31	4				
Mild or absent	10	19	19/29 = 65%	31/35 = 88.5%	< 0.05	s
Total	41	23				

(31,45,46). MDCT evaluation of appendicitis, the most common cause of acute abdominal pain requiring emergency surgery, has been extensively studied. Because it has high accuracy in diagnosis of not only appendicitis but also potential complications such as perforation and abscess formation, it is considered the imaging method of choice in patients with ARLQP (47,48). There is much less published data and awareness about less common causes of ARLQP. The list of differential diagnoses is vast, and accurate assessment of CT features of these conditions is of major importance for appropriate selection of patient treatment, as it may prevent unnecessary hospital admission or surgery (49,50). Consequently, the radiologist should be familiar with the MDCT features of the spectrum of diseases affecting this area to help ensure correct diagnosis and appropriate treatment (5,43).

MDCT may offer distinct advantages over the traditional single-detector row CT in the evaluation of inflammatory conditions and complications of tumors of the ileocecal area, mainly, obstruction and intussusceptions. With recent scanners, it is now possible to scan the entire abdomen and pelvis within a breath hold at a resolution of less than 1 mm (0.5–0.75 mm) in the *x*, *y*, and *z* axes. Thinner collimation and faster scanning increase resolution and decrease respiratory and motion artifact, especially in patients with severe bowel obstruction, who are often in severe pain (43). The availability of additional planes is appreciated by surgeons and often increases the confidence of radiologists in dealing with difficult cases of inflammation, obstruction and intussusception (51).

Differentiation between an acute inflammatory condition and malignancy at CT is not always an easy task, since findings may overlap. The target sign was first described by Balthazar (40) as a series of three concentric high-, low-, and high-attenuation layers of the intestinal wall at contrast-enhanced CT. One of the great utilities of this sign is that it reflects a histologically benign condition resulting in the expansion of the submucosal layer of the intestinal wall by edema, inflammatory infiltration, blood products, or fat. In our study, a stratified enhancement pattern in a thickened segment of bowel wall producing a double halo or target sign, was reliable to indicate an active benign inflammatory condition in 33 cases with a +ve predictive value of 71.4% and −ve predictive value of 91.6% and *P* value of < 0.005.

A different target appearance was described by Gollub and his colleagues in some patients with metastatic disease from scirrhous-type primary lesions such as gastric, breast, and bladder cancers. The malignant target signs were seen most typically in the rectum or other parts of the colon and occasionally other parts of the gastrointestinal tract as thickened hyperattenuating outer and inner layers and a hypoattenuating thin intervening layer. This appearance differs from the classic target sign by the disproportionate thickening of the hyperattenuated outer and inner layers to the intermediate thin hypoattenuated layer, irrespective of the segment of the gastrointestinal tract involved (52).

Although inflammatory or neoplastic conditions may overlap in terms of the length of bowel involved, the analysis helps in narrowing the differential diagnosis (31). With few

exceptions (including 5 lymphomas), long segments of involvement (10 cm or longer) indicated a benign condition in 29 cases whereas short focal bowel wall thickening correctly suggested a malignant process in 17 cases with a −ve PV of 85% and a +ve PV of 60% and a P value of <0.05.

Another variable that aids in establishing the diagnosis is the degree of bowel wall thickening. In general, benign conditions result in bowel wall thickening of less than 2 cm, whereas wall thickening greater than 3 cm usually indicates a neoplastic condition. However, entities that cause mild bowel wall thickening often overlap, and wall thickening may be marked in infectious or ischemic processes (9). Our results correlated to a satisfactory degree with these statements with a −ve predictive value of 86.6% and +ve predictive value of 55.8%.

Malignancy more often appears as a concentric mass with overhanging shoulders and abrupt transition from abnormal to normal bowel. Smooth symmetric bowel wall thickening with gradual transition is commonly associated with benign inflammatory conditions (17,53,54). This sign suggested malignancy in 17 cases and excluded malignancy in 35 cases with +ve PV and −ve PV of 74% and 85%, respectively.

According to the literature, fat stranding adjacent to a thickened bowel segment, especially if disproportionately more severe than the degree of wall thickening, are also findings that favor an acute inflammatory process (40). When the perienteric fat adjacent to a thickened bowel segment is normal, an acute inflammatory condition is less likely. Fat stranding that is disproportionately more severe than the degree of wall thickening is one of the findings that allow differentiation between inflammatory diseases and suggests diverticulitis, appendicitis, or epiploic appendagitis (20,55).

Several limitations existed in this study: (1) lack of histopathological diagnosis in 20 cases. (2) The diversity of investigated lesions including variable inflammatory, infective, ischemic and neoplastic conditions. (3) Reliance upon multiple covariates to establish the diagnosis which reduces the exclusive diagnostic reliability of each parameter. (4) Previous similar studies discussing the same topics lack statistical data to compare with those of our results.

6. Conclusion

Using a systematic pattern approach MDCT has proved to be an extremely useful noninvasive method for evaluation of patients with ARLQP, allowing diagnosis and management of not only the most common condition which is acute appendicitis but also many other benign and malignant gastrointestinal pathological entities. The attenuation pattern of the enhanced thickened bowel wall and the transition zone from normal to abnormal bowel were the most significant variables allowing differentiation between benign and malignant conditions and their combination yielded higher predictive values than those obtained when using each variable alone.

Conflict of interest

We have no conflict of interest to declare.

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